ECE 445

SENIOR DESIGN LABORATORY

FINAL REPORT

Fire Detection and Suppression System for Electric Ranges

Team #33

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Abstract

This document provides an overview of the design process for the Fire Detection and Suppression System for Electric Ranges. This includes the high level design of the system, associated materials and costs to build the system, technical discussions for design decisions, results and finally areas to improve upon. The final product is able to detect which burners are on as well as detect fires and react accordingly.

Contents

1 Introduction

In the United States, over half of house fires originate from the stove-top and of those, electric ranges were 2.5x more likely to have caused the fire[1]. Most households simply rely on a smoke detector placed in the vicinity of the kitchen in order to detect a fire and take appropriate action. However, these smoke detectors are often too slow at detection and by the time action has been taken, there is already risk to property and life. Our goal was to create a system that could detect and suppress fire that originate from an electric range at a more local level in order to reduce the time between the start of a fire and the mitigation of said fire.

From here we decided on three requirements that our system needed to be able to accomplish for our envisioned system:

1. Our device should be able to detect the number of burners that are one within 15 seconds of a change to the burners
2. Our device should be able to begin actuating the suppressant system and shut off power to the range within 3.5 seconds of an active fire
3. Our device should be able to actuate the suppressant mechanism, in our final demo this will be a laser pointer, within 4 seconds after the power to the range has been shut off

With the function of the system decided, we split the project into 4 sections as shown by our block diagram in Figure 1:

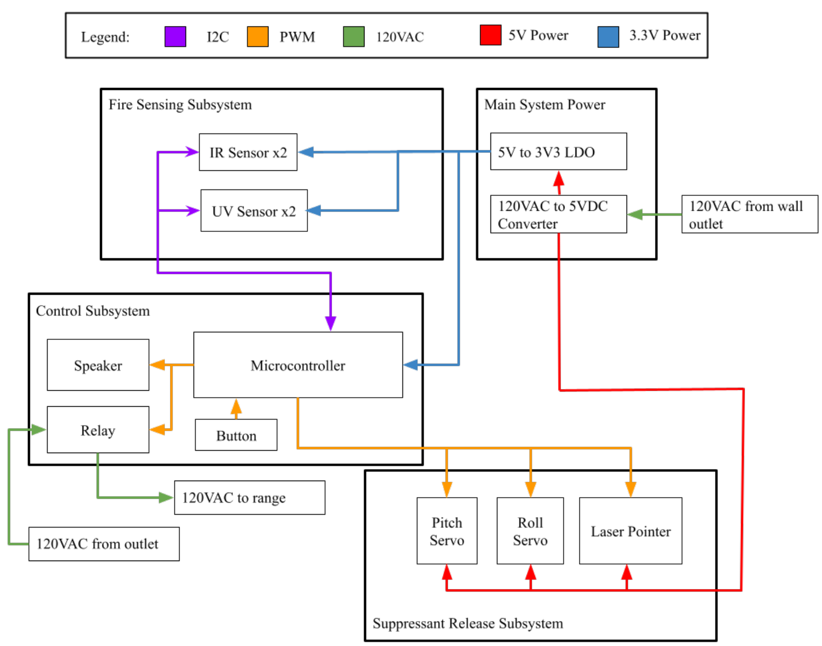

Figure 1: Block Diagram

The main system power subsystem handles converting from 120VAC down to the voltages needed by other subsystems. A key performance requirement of this subsystem is the AC adaptor used must be capable of supplying greater than 3A.

The fire sensing subsystem captures relevant data for the control subsystem to process. A key performance requirement here is the ranged temperature sensor used must have a precision of $\pm 1°C$. A change made in this subsystem is the removal of the UV sensor

The suppressant release subsystem handles aiming and release the fire suppressant. No change was made with this subsystem.

The control subsystem is responsible for processing the data from the sensors and and actuating different components. A key performance requirement is the chosen relay must be capable of handling the amperage and voltage of the plug type used. In our case, this is 120VAC at 15A.

The physical design of the unit also changed from the initial plan and the difference between the 2 units is shown in Figure 2:

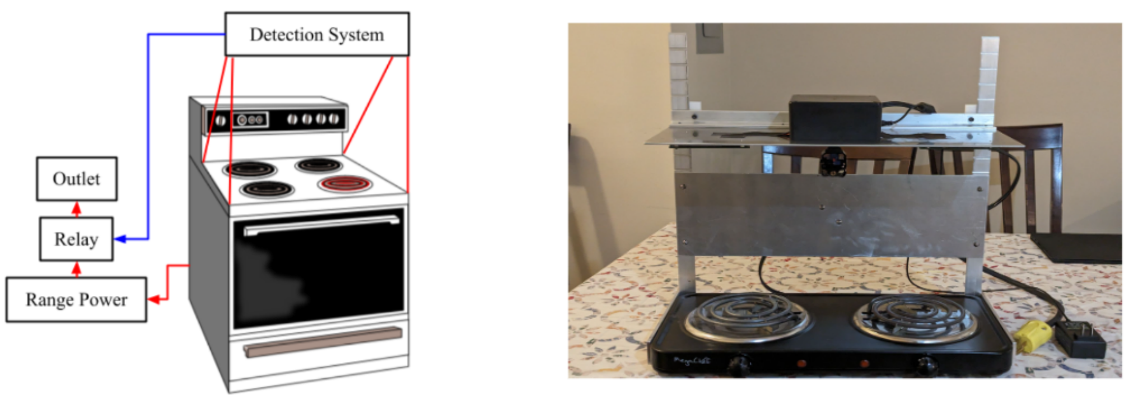

Figure 2: Initial Physical Design(left) vs Final Design(right)

2 Design

Throughout the entirety of this project, there have been no major changes to the functional design of the system as well as its implementation. Minor changes to the system allowed the system to be functional in the end.

2.1 Design Procedure

Upon the initial design, the location of its intended use was considered to determine a power source. The device is designed to be mounted above a range or stove and not meant to be portable. The power source was determined to come from a standard US outlet (duplex NEMA 15 receptacle) down to 5VDC due to its fixed location and majority system component voltages. Batteries were also included in the discussion, however due to the temperature of the mounted location, it was ruled to be dangerous. To achieve a system operating voltages (5V and 3V3), a linear dropout regulator was opted instead of a buck converter, which is explained in the next section. This was the design process for the power subsystem.

For the sensing subsystem, two different sensor types were identified: IR for heat detection and UV for fire detection. This came from the fact that a burner could be on (i.e. someone cooking), but not necessarily have a fire. The inclusion of the UV sensor was to prevent false positives in fire detection, as fire emits a certain wavelength. However, for the final system design, the UV sensor was not integrated into the final product. This is the only change in the original block diagram for the system. Unfortunately, the UV sensor was not able to be integrated into our system due as the pads bridged during reflow. Several techniques were applied to try to get the sensor to work properly, but the IR sensor proved that it was able to handle fire detection with heat pretty accurately.

Designing the suppressant system was fairly straightforward. It would need a way to aim and a way to activate the suppressant. Originally, a solenoid valve was planned to launch a suppressant (fire extinguisher, foam, water, etc.). For a final design, a proof of concept was implemented as a laser pointer with additional input from mentors in the machine shop. With this light device, a pan/tilt servo was chosen to aim the mechanism. This also came from recommendation from the machine shop.

The control subsystem should be able to talk to each system by processing data from the sensing subsystem to activate the suppressant system. The chosen microcontroller was the ESP-32 S3 as some members had prior experience with this MCU.

2.2 Design Details

An important part of the control system design is that it simply controls, not powers the elements. Power should be supplied from the power subsystem. Figure 3 depicts the net labels for the corresponding control signal.

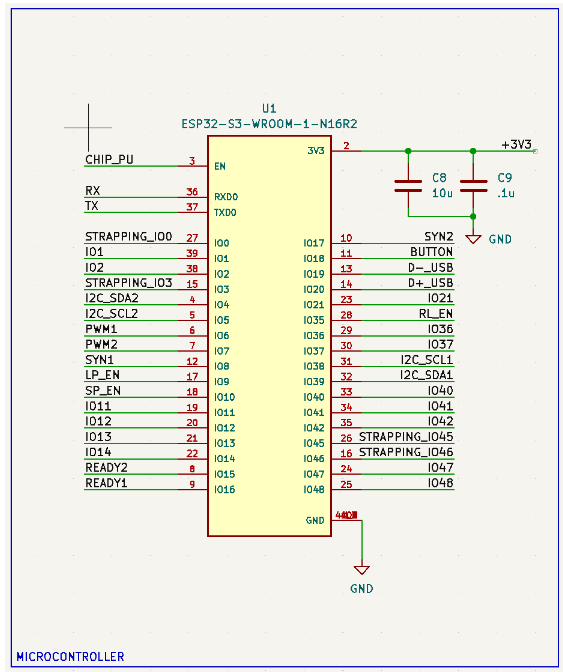

Figure 3: ESP-32 Connections

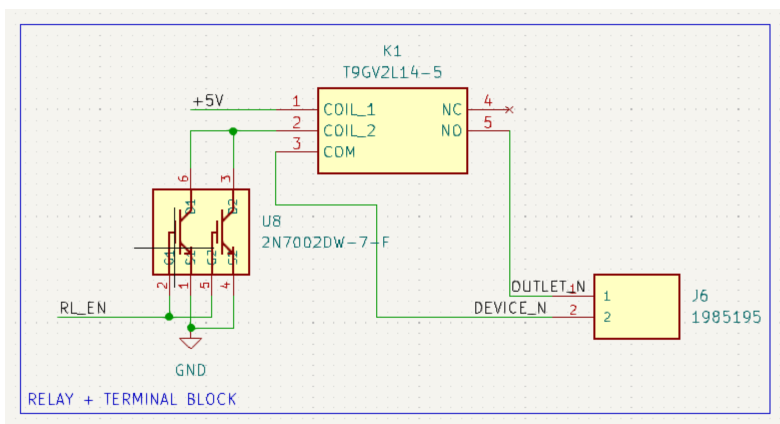

Figure 4: Relay Circuitry

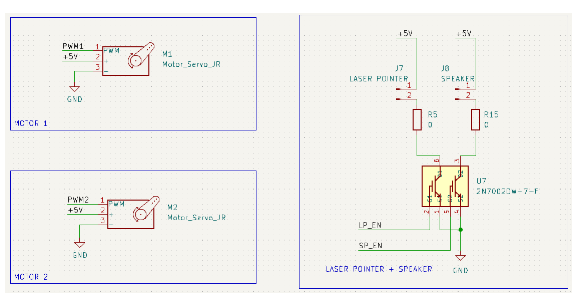

Figure 5: Suppressant Subsystem

As depicted in Figures 4 and 5, the components are powered through the +5V rail and controlled by an NMOS, gated by the MCU IO lines. This ensures that the MCU does not limit the power to the devices, like the relay.

In regards to the relay power [2], it has an operating voltage of 5VDC and operating coil current of 180mA. The chosen NMOS [3] has a rated drain current of 180mA as well. Because of this, the relay is controlled by a dual NMOS channel to relieve some current through a singular NMOS.

Two voltage converters were considered when designing the power subsystem: a linear dropout regulator vs. a buck converter. The differences between these two lie in the efficiency of the device, where the LDO has a lower efficiency with a greater voltage difference between input/output voltages, and the output noise of the device. The buck converter uses a switching latch to provide the output voltage, which causes a lot of noise on the line. We calculated the maximum current supplied on the 3V3 line to be 254mA. This comes from the max current pulled through the MCU as 200mA, and IR sensors with 27mA. The power dissipated through the LDO comes from the difference in the input voltage and the output current, as shown in Equation 1.

$$P_{dis} = (V_{in} - V_{out})I = .4318\ W \tag{1}$$

The thermal rise of the LDO comes from the different package size. With this specific size (DPAK, TO-252), we have a thermal junction rise of 10°C/W. Therefore, the thermal rise comes out to be 4.318°C from the LDO. With this low temperature rise, there was no need to consider the buck converter to introduce potentially harmful noise into our system. Fi

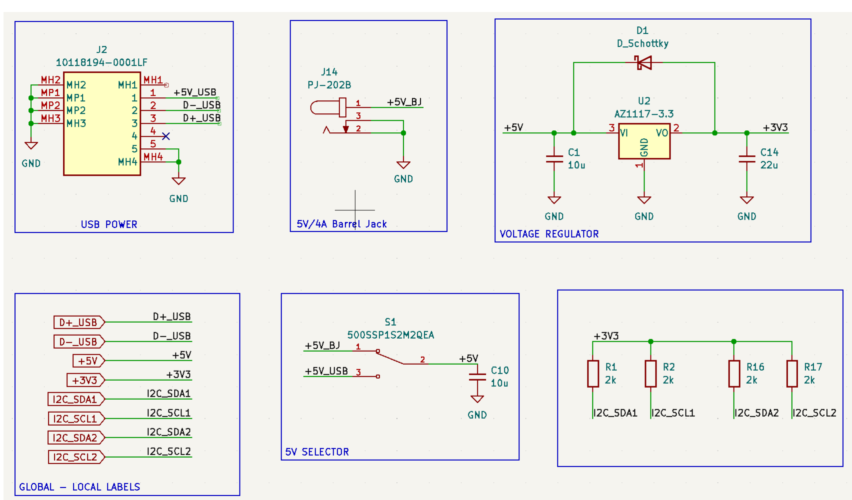

Figure 6: Power Subsystem

Figure 6 shows thew power subsystem circuitry. Initially, power was to be supplied by a USB, but deemed to be lacking the current necessary for the servos, which introduced the

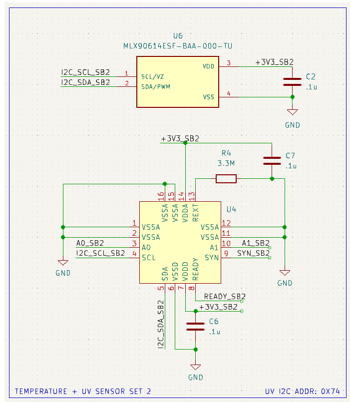

Figure 7: Sensing Subsystem

barrel jack connector. The USB remained there to supply power during programming. The main system 5V supply is selected by the power switch. Figure 7 shows the circuitry for the sensors. They are designed so that the same board could be used for the main board as well as the sensor boards. This design is shown in figure 8

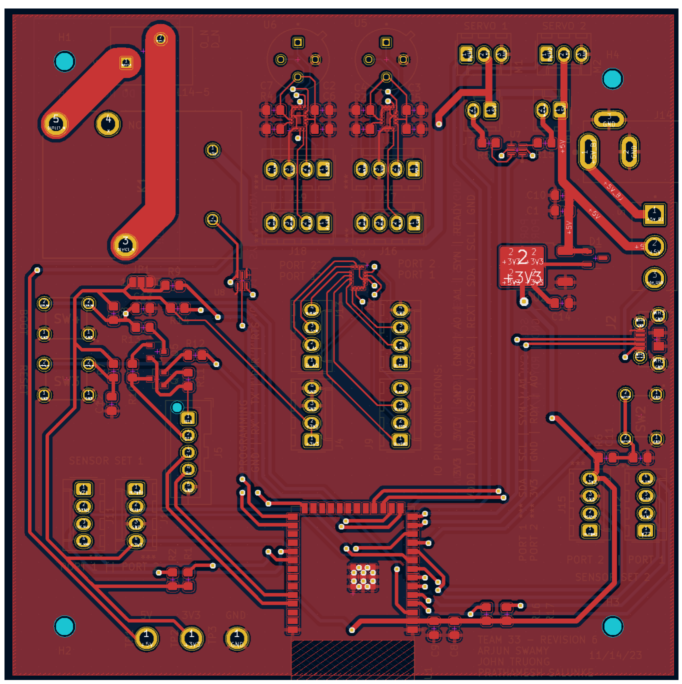

Figure 8: PCB Design

With the locations of the burners known and the height of the hood set, we can get the angles that the pan and tilt servos need to be at for the laser pointer to be shown at the correct location. From here we needed to calculate the pulse-width of the pwm signals for each of the servos, as the SG-90 servos used are closed-loop servos and need the pulse-width of the pwm signal to correlate to the angle. The equation used to calculate this pulse width is shown in Equation 2:

$$(angle - MIN\_DEGREE) * \frac{(PULSEWIDTH\_DIFF)}{(RANGE)} + MIN\_PULSEWIDTH \quad (2)$$

Where $PULSEWIDTH\_DIFF = MAX\_PULSEWIDTH - MIN\_PULSEWIDTH$

and $RANGE = MAX\_DEGREE - MIN\_DEGREE$

The reason for these placeholders is that, while the servos used are the same model, due to the pan-tilt enclosure they are in, the min and max angle and the corresponding pulse-widths change depending on which servo. By using the provided datasheet and a protractor to verify the resulting angles, we found for the relevant pulse-widths need for the servos. Table A1 shows the min and max angles and their respective pulse-widths for the pan servo and Table A2 does the same for the tilt servo.

Table 1: Pan Servo Pulse-widths

Measured angle °	Pulse-width of PWM provided in μs
-90(min)	440
+90(max)	2400

Table 2: Tilt Servo Pulse-widths

Measured angle °	Pulse-width of PWM provided in μs
0(min)	1500
+90(max)	2475

3 Verification

3.1 Subsystem Overview

3.1.1 System Power Subsystem

All of the power subsystem requirements were met. This was measured through input voltage coming from the barrel jack, measured to be 5.44V, which remains in range for the system requirements. The output voltage of the LDO was kept at 3.3±.1V. With the max expected current pull through the LDO to be 254mA, we verify the final requirement of the power subsystem.

Table 3: Power Subsystem RV Table

Requirements	Verification	Results
IR and MCU receive $3.3V \pm 0.2V$	1. Prepare a digital multi-meter and measure the voltage across a ground point on the PCB and the part you are testing 2. Ensure the voltage is within the designated spec 3. Repeat until IR and MCU have been tested	3.35V, 3.29V, 3.31V
Speaker, Relay, Servo, and Laser Pointer receive $5V \pm 0.5V$	1. Prepare a digital multi-meter and measure the voltage across a ground point on the PCB and the part you are testing 2. Ensure the voltage is within the designated spec 3. Repeat until all components have been tested	4.95V, 5.02V, 5.08V
Linear regulator supplies a maximum of 300mA	1. Prepare a digital multi-meter and measure the voltage across the shunt resistor 2. Divide the voltage by the resistance of the shunt resistor to find the LDO supply current 3. Ensure this value is within the specification	110mA, 102mA, 114mA

3.1.2 Fire Sensing Subsystem

The fire sensing subsystem performed reliably for the system functionality. There was no proper way to determine how accurate the sensor readings were, however, when printing out the readings on the serial monitor, the device gave us readings as expected. High temperatures read a large value (70-200°), fires even larger(300°), and cold read lower values (¡70°). There was no way to test the UV sensor as we were never able to implement the component in our system.

Table 4: Sensing Subsystem RV Table

Requirements	Verification	Results
IR sensor must be capable of accurately measuring the temperature of the measured area within $\pm 1.5 \deg C$	1. Establish communication with the sensor and display the measured temperature value via log output 2. Using a heat-generating device with a known heat output such as a digital hotplate, position the sensor 16 inches above the device and start the heat-generating device 3. Allow the heat-generating device sufficient time to stabilize 4. Compare the output of the sensor in the log with the temperature that the heat-generating device was set to and ensure it is within $\pm 1.5 \deg C$	45.2°C, 44.8°C, 45.0°C

3.1.3 Control Subsystem

The Control Subsystem is responsible for accumulating and processing the data given by the Fire Sensing Subsystem and subsequently using that data to determine an action for the Suppressant Release Subsystem and the kill-switch relay. The core of the Control Subsystem is the ESP32-S3 microcontroller that will be responsible for I2C communication to and from the sensors as well as the analog outputs needed to actuate the suppressant release subsystem. The other components are the speaker and relay, which will be triggered when the microcontroller detects a fire, and a button that allows the end user to override the microcontroller and stop the suppressant release if the user knows there will be a fire. This subsystem will require 3.3V to be supplied by the power subsystem.

The control susbsystem was able to determine which burner was on in the allotted time. The longest time we measured was at 14 seconds, with ambient temperatures at around 0°C. It would signal which side the burner is on by giving 1 beep or 2 for the left or right side. Though the control subsystem did not point at the specific burner continuously, when a fire was detected, it performed as required by aiming at the burner on fire.

Table 5: Control System RV Table

Requirements	Verification	Results
Micro-controller must be able to determine which burner(s) are turned on within 10 $\pm$ 5 seconds of a change to the burners	1. Ensure the heating elements of the range are off and are at or near room temperature, with the IR sensors placed 1 foot above both heating pads 2. Setup the micro-controller so that the detected burner is outputted to the log and prepare a stopwatch 3. Start the stopwatch and simultaneously switch on one of the heating pads in the range. 4. Stop the stopwatch when the correct burner is outputted by the micro-controller to the log and ensure the time is within the specification 5. Repeat for all configurations of the 2 burners setup	8s, 9s, 10s
The microcontroller must be able to determine the location of a fire within 2.5 $\pm$ 1 seconds of an active fire within the sensing area	1. Ensure the heating elements of the range are off and are at or near room temperature, with the IR placed 1 foot above both heating pads 2. Setup the micro-controller such that the detected fire and its location are outputted to the log and prepare a stopwatch and a matchbox 3. Start the stopwatch and simultaneously light a match next to one of the burners 4. Stop the stopwatch when the correct burner is outputted by the micro-controller to the log and ensure the time is within spec 5. Repeat for the other burner location	2.2s, 2.5s, 2.4s
After fire detection, a sound must play from the onboard speaker	1. Ensure the heating elements of the range are off and are at or near room temperature, with the IR sensors placed 1 foot above both heating pads, and prepare a matchbox 2. Light a fire using a match and confirm that an audible sound is emitted	Yes, Yes, Yes
After fire detection, the micro-controller must trigger the relay within 2.5 $\pm$ 1 seconds	1. Ensure the heating elements of the range are off and are at or near room temperature, with the IR sensors placed 1 foot above both heating pads, and prepare a matchbox and a stopwatch 2. Using a bench power supply, supply 5V on the input side of the relay and ensure that 5V is measured on the other side using a multi-meter 3. Start the stopwatch and light a fire using a match 4. Stop the stopwatch when the multi-meter measures 0V ± 0.05 and ensure that the time is within spec	2.3s, 2.4s, 2.2s

3.1.4 Suppressant Release Subsystem

The Suppressant Release Subsystem handles the aiming and the release of the fire suppressant in the area determined by the Control Subsystem. This subsystem was properly verified to work through our requirements. The servo would immediately move to aim at the burner on fire even within 1 second of fire detection, surpassing the minimum requirement of our system and to the specified tolerance of 5°.

Table 6: Suppressant Release RV Table

Requirements	Verification	Results
Servos must be able to position the suppressant mechanism according to the location provided by the control subsystem within $5\,\mathrm{deg}$	1. Connect the pan and tilt servos to the micro-controller 2. Determine angles to be tested for both pan and tilt 3. Supply the PWM signal corresponding to the determined angles to the servos and measure the resulting angles with a protractor 4. Ensure the angle is within spec and repeat with different angle tests within the sensing area	3.8°, 4.2°, 4.0°
Servos must position the suppressant mechanism within 3 ± 1 seconds	1. Connect the pan and tilt servos to the micro-controller and prepare a stopwatch	Yes, Yes, Yes

4 Costs

4.1 Cost Analysis

The total cost for parts as seen below before shipping is \$83.80. 5% shipping cost adds another \$4.190 and 10% sales tax adds another \$8.380. We can expect a salary of \$40/hr×2.5 hr×60 = \$6000 per team member. We need to multiply this amount by the number of team members: \$6000× 3 = \$18,000 in labor costs. This comes out to be a total cost of \$18095.79

4.1.1 Parts List

Table 7: Itemized list of Components and Costs

Part Number	Manufacturer	Quantity	Unit Price	Link
ESP32-S3-WROOM-1-N4	Espressif Systems	1	\$2.95	Link
MLX90614ESF-BAA-000-TU	Melexis	2	\$18.53	Link
1967 (Servo)	Adafruit	1	\$18.95	Link
1054 (Laser Pointer)	Adafruit	1	\$5.95	Link
T9GV2l14-5	TE Connectivity	1	\$3.44	Link
AZ1117C-3.3TRG1	Diodes Incorporated	1	\$0.45	Link
AL-0540	Facmogu	1	\$9.99	Link
SPKM.15.8.A	Taoglas Limited	1	\$1.74	Link
500SSP1S2M2QEA	E-Switch	1	\$3.27	Link

Total = \$83.80

4.2 Schedule

Week of	Task	Member
9/18	Component Research	John
	Order prototype parts	Arjun
	Machine Shop Discussion	Arjun
9/25	PCB Design and more Component Selection	John
	Begin breadboarding	Arjun
	Fire Detection algo brainstorm	Prathamesh
10/2	PCB Design	John
	Waiting for parts,	Arjun
	Waiting for parts	Prathamesh
10/9	PCB Design	John
	Continue breadboarding, finalize machine shop plans	Arjun
	Continue algo research	Prathamesh
10/16	PCB revisions	John
	Basic servo movement and laser pointer toggling	Arjun
	Communicate with IR sensor	Prathamesh
10/23	PCB Revisions and Component Testing	John
	Component testing	Arjun
	Verification of parts	Prathamesh
10/30	PCB Revisions and Power Subsystem Testing	John
	Control subsystem testing	Arjun
	Verification of parts	Prathamesh
11/6	PCB Revisions and Sensing Subsystem Testing	John
	Suppression system	Arjun
	Communication with both IR sensors	Prathamesh
11/13	PCB Revisions and UV Sensor Testing	John
	Control system and Suppression system integration	Arjun
	Algo implementation for IR	Prathamesh
11/20	Integration with all subsystems	Everyone
11/27	Final product, begin working on demo and presentation	Everyone

5 Conclusion

In summary, our project addresses the critical issue of fires in residential kitchens by presenting a comprehensive Fire Detection and Suppression System. This system achieved through successful PCB design, sensor integration, and a proof-of-concept for fire suppression, ensures user safety and property protection.

5.1 Successes

The development of a single-board design with an optimized layout facilitated efficient component integration, enhancing the overall system functionality. Integration of infrared (IR) sensors enabled fast and precise temperature measurements for reliable fire detection. The proof-of-concept demonstrated a quick response to identified fires, a safe mode by turning the range off, and the capability of alerting users through a speaker.

5.2 Lessons Learned

Skills such as reading datasheets became crucial to ensuring accurate component integration and adherence to specifications. Identifying and resolving issues in the printed circuit board (PCB) design enhanced our troubleshooting skills. Hands-on experience with surface-mount device (SMD) soldering and reflow techniques provided practical insights into manufacturing considerations.

5.3 Areas of Improvement

Implementing a peer review process during the design phase could enhance overall project quality and reduce the likelihood of errors. Improved time management strategies would streamline development processes and potentially accelerate project milestones. Conducting preliminary testing with sensor modules before full integration could identify sensor-specific challenges early in the development process.

Exploring the integration of a real fire suppressant system as opposed to just a proof of concept in future iterations would enhance the system's effectiveness. Incorporating additional sensors, such as gas or smoke detectors, could further improve the system's ability to detect and respond to various fire conditions. Designing the system to be compatible with existing vent hoods would simplify adoption in residential kitchens without requiring significant modifications.

5.4 Ethical Considerations

Our project aligns with the following IEEE Code of Ethics, prioritizing accuracy in communication, product safety, and transparency in system operation.

Accuracy and False Positives/Negatives (IEEE Code of Ethics 1.2): We successfully ensured the system's accuracy in detecting fires without generating false alarms, ensuring the avoidance of unnecessary disruptions and costs for users. To avoid ethical breaches, we conducted rigorous testing of our sensors to avoid false breaches.

Safety of End-Users (IEEE Code of Ethics 3.7): The system's primary purpose was to enhance safety. We ensured that the system does not introduce new risks or vulnerabilities and that it reliably performs its safety functions, such as turning off burners, without endangering users.

Transparency (IEEE Code of Ethics 2.6): Clear documentation, such as the design document and project presentations will help achieve transparency with users.

5.5 Broader Impacts

Beyond immediate safety implications, our project has economic, environmental, and societal impacts. Prevention of kitchen fires reduces property damage and insurance claims, positively impacting the economy. The system's rapid response minimizes the release of harmful substances, contributing to a safer living environment.

In conclusion, our Fire Detection and Suppression System represents a significant step toward enhancing safety in residential kitchens.

Appendix A Tables and Figures

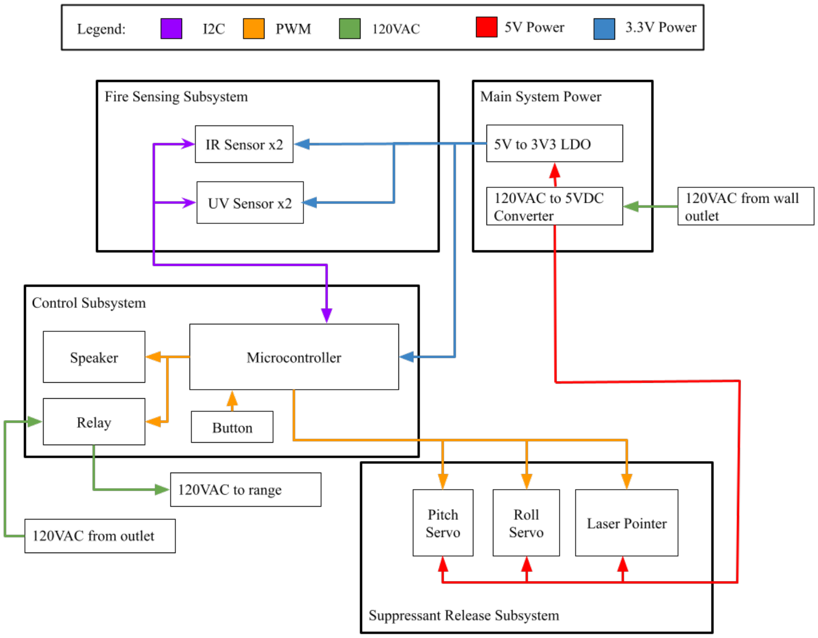

Figure 1: Block Diagram

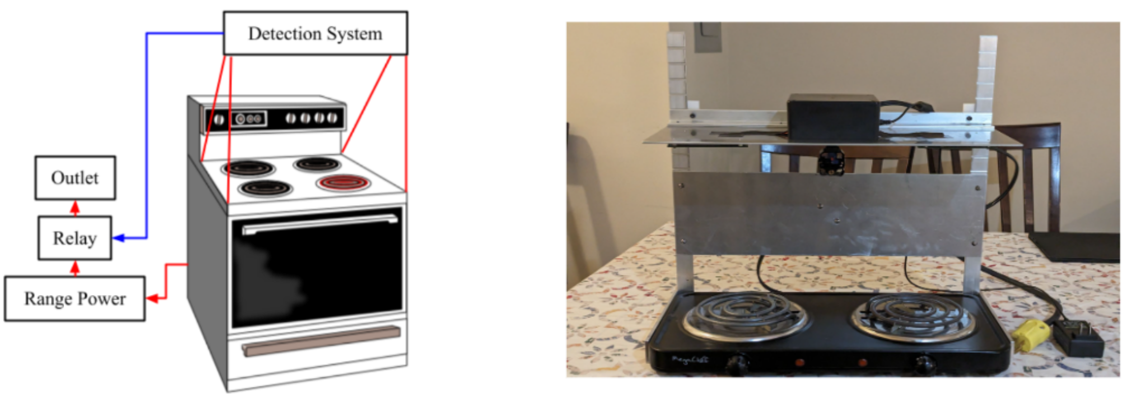

Figure 2: Initial Physical Design(left) vs Final Design(right)

Table A1: Pan Servo Pulse-widths

Measured angle °	Pulse-width of PWM provided in μs
-90(min)	440
+90(max)	2400

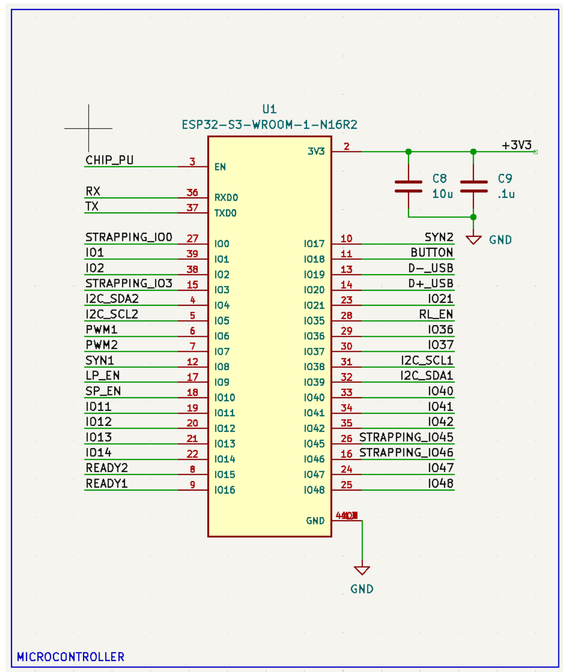

Figure 3: ESP-32 Connections

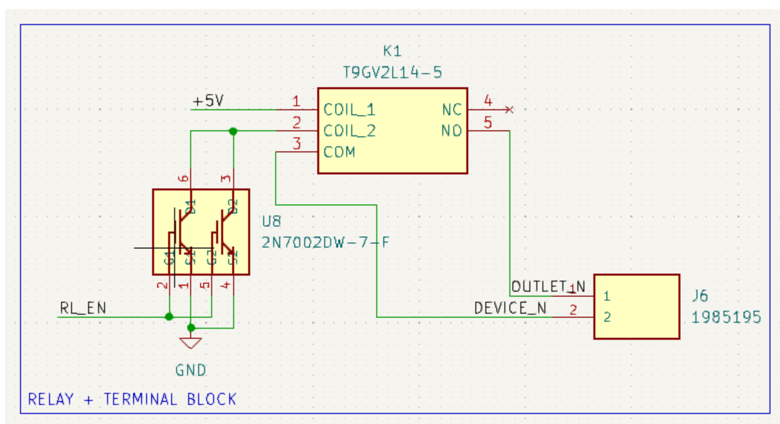

Figure 4: Relay Circuitry

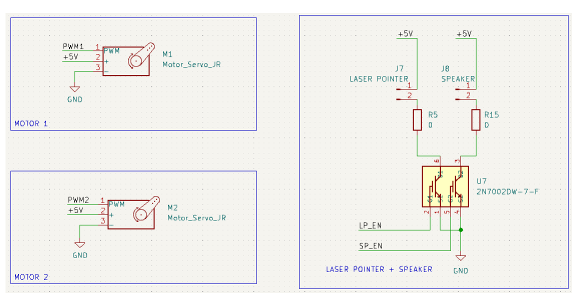

Figure 5: Suppressant Subsystem

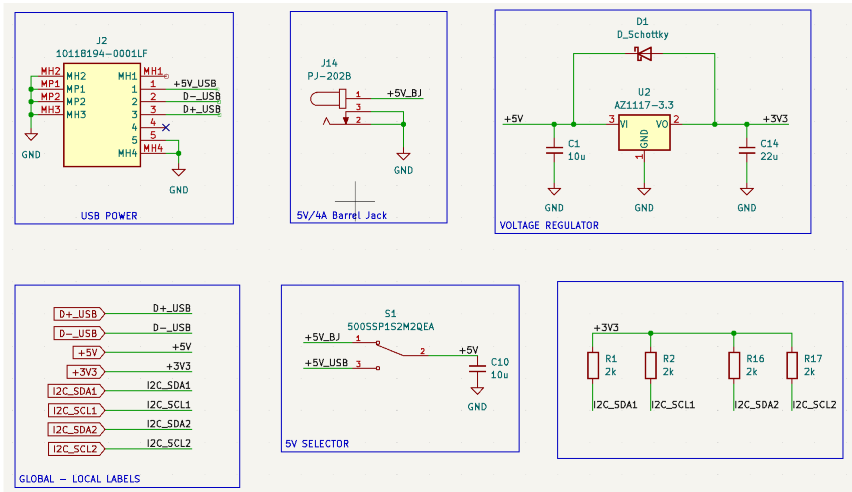

Figure 6: Power Subsystem

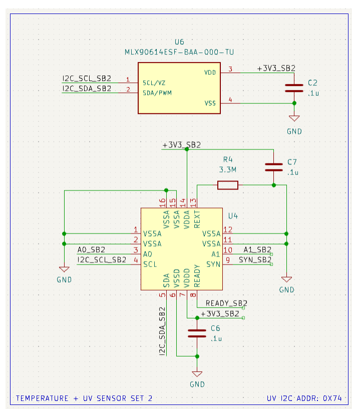

Figure 7: Sensing Subsystem

Table A2: Tilt Servo Pulse-widths

Measured angle °	Pulse-width of PWM provided in μs
0(min)	1500
+90(max)	2475

Table A3: Power Subsystem RV Table

Requirements	Verification	Results
IR and MCU receive $3.3V \pm 0.2V$	1. Prepare a digital multi-meter and measure the voltage across a ground point on the PCB and the part you are testing 2. Ensure the voltage is within the designated spec 3. Repeat until IR and MCU have been tested	3.35V, 3.29V, 3.31V
Speaker, Relay, Servo, and Laser Pointer receive $5V \pm 0.5V$	1. Prepare a digital multi-meter and measure the voltage across a ground point on the PCB and the part you are testing 2. Ensure the voltage is within the designated spec 3. Repeat until all components have been tested	4.95V, 5.02V, 5.08V
Linear regulator supplies a maximum of 300mA	1. Prepare a digital multi-meter and measure the voltage across the shunt resistor 2. Divide the voltage by the resistance of the shunt resistor to find the LDO supply current 3. Ensure this value is within the specification	110mA, 102mA, 114mA

Table A4: Sensing Subsystem RV Table

Requirements	Verification	Results
IR sensor must be capable of accurately measuring the temperature of the measured area within $\pm 1.5 \deg C$	1. Establish communication with the sensor and display the measured temperature value via log output 2. Using a heat-generating device with a known heat output such as a digital hotplate, position the sensor 16 inches above the device and start the heat-generating device 3. Allow the heat-generating device sufficient time to stabilize 4. Compare the output of the sensor in the log with the temperature that the heat-generating device was set to and ensure it is within $\pm 1.5 \deg C$	45.2°C, 44.8°C, 45.0°C

Table A5: Control System RV Table

Requirements	Verification	Results
Micro-controller must be able to determine which burner(s) are turned on within 10 ± 5 seconds of a change to the burners	1. Ensure the heating elements of the range are off and are at or near room temperature, with the IR sensors placed 1 foot above both heating pads 2. Setup the micro-controller so that the detected burner is outputted to the log and prepare a stopwatch 3. Start the stopwatch and simultaneously switch on one of the heating pads in the range. 4. Stop the stopwatch when the correct burner is outputted by the micro-controller to the log and ensure the time is within the specification 5. Repeat for all configurations of the 2 burners setup	8s, 9s, 10s
The microcontroller must be able to determine the location of a fire within 2.5 ± 1 seconds of an active fire within the sensing area	1. Ensure the heating elements of the range are off and are at or near room temperature, with the IR placed 1 foot above both heating pads 2. Setup the micro-controller such that the detected fire and its location are outputted to the log and prepare a stopwatch and a matchbox 3. Start the stopwatch and simultaneously light a match next to one of the burners 4. Stop the stopwatch when the correct burner is outputted by the micro-controller to the log and ensure the time is within spec 5. Repeat for the other burner location	2.2s, 2.5s, 2.4s
After fire detection, a sound must play from the onboard speaker	1. Ensure the heating elements of the range are off and are at or near room temperature, with the IR sensors placed 1 foot above both heating pads, and prepare a matchbox 2. Light a fire using a match and confirm that an audible sound is emitted	Yes, Yes, Yes
After fire detection, the micro-controller must trigger the relay within 2.5 ± 1 seconds	1. Ensure the heating elements of the range are off and are at or near room temperature, with the IR sensors placed 1 foot above both heating pads, and prepare a matchbox and a stopwatch 2. Using a bench power supply, supply 5V on the input side of the relay and ensure that 5V is measured on the other side using a multi-meter 3. Start the stopwatch and light a fire using a match 4. Stop the stopwatch when the multi-meter measures 0V ± 0.05 and ensure that the time is within spec	2.3s, 2.4s, 2.2s

Table A6: Suppressant Release RV Table

Requirements	Verification	Results
Servos must be able to position the suppressant mechanism according to the location provided by the control subsystem within $5\,\mathrm{deg}$	1. Connect the pan and tilt servos to the micro-controller 2. Determine angles to be tested for both pan and tilt 3. Supply the PWM signal corresponding to the determined angles to the servos and measure the resulting angles with a protractor 4. Ensure the angle is within spec and repeat with different angle tests within the sensing area	3.8°, 4.2°, 4.0°
Servos must position the suppressant mechanism within 3 ± 1 seconds	1. Connect the pan and tilt servos to the micro-controller and prepare a stopwatch	Yes, Yes, Yes

Table A7: Itemized list of Components and Costs

Part Number	Manufacturer	Quantity	Unit Price	Link
ESP32-S3-WROOM-1-N4	Espressif Systems	1	$2.95	Link
MLX90614ESF-BAA-000-TU	Melexis	2	$18.53	Link
1967 (Servo)	Adafruit	1	$18.95	Link
1054 (Laser Pointer)	Adafruit	1	$5.95	Link
T9GV2l14-5	TE Connectivity	1	$3.44	Link
AZ1117C-3.3TRG1	Diodes Incorporated	1	$0.45	Link
AL-0540	Facmogu	1	$9.99	Link
SPKM.15.8.A	Taoglas Limited	1	$1.74	Link
500SSP1S2M2QEA	E-Switch	1	$3.27	Link

References

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